MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2015/2016

EOP 4076 – LASER TECHNOLOGY & APPLICATIONS

(OPE)

9 MARCH 2016
2.30 p.m – 4.30 p.m
(2 Hours)

INSTRUCTION TO STUDENT

1. This Question paper consists of 6 pages including cover page with 4 Questions only.

2. Attempt **ALL** questions. Each question may carry different marks and the distribution of the marks for each question is given.

3. Please print all your answers in the Answer Booklet provided. Please number your answers clearly.

Question 1

(a) You are leading a project to build pulsed lasers, and you are proposing to your team to apply the Q-switching approach. Explain to your teammates the process of *Q-switching*, and illustrate the evolution of a Q-switched laser pulse, showing the loss, gain and laser output on the same graph.

[5 marks]

(b) You requested a laser source emitting at 488 nm from two different vendors. However, each vendor is offering a laser source with a linewidth of 30 MHz and 50 MHz, respectively. Using appropriate formulas, choose which laser source is having a longer temporal coherence length.

[4 marks]

(c) The average value of the transition probability, A_{ul} for the upper laser state to lower laser state of Hidrogen (H) is 4.7×10^8 s^{-1}. A mixture of Helium (He) in H will affect the transition probability by a factor of 10^7 $s^{-1}Torr^{-1}$. If 10 Torr of He gas is added to an electrical discharge composed of H atoms, evaluate the change of lifetime, τ_u of the upper laser state of H.

[4 marks]

(d) A Rodamine-B dye mixture in Ethyl alcohol (EtOH) emits over a spectral bandwidth, $\Delta\lambda$ ranging from 525 to 625 nm, with a peak spontaneous emission wavelength of 565 nm. Assume that the emission is homogeneously broadened and that the emission originates from the lowest energy of the S_1 level. Evaluate the energy width, ΔE of the lower level S_0 to which transitions occur from S_1.

[4 marks]

Continued...

Question 2

(a) The excimer laser is produced through emission from excited-state species of the excimer molecules in the upper laser level. Explain in detail, the formation processes of these laser species in an ArF excimer laser.

[6 marks]

(b) Your company desires to start production on mode-locked Titanium Sapphire lasers. You are appointed as the lead laser designer, where you have decided to apply the intra-cavity *mask* aperture technique. Prepare a brief write-up with a suitable diagram to make your teammates understand its working principle.

[7 marks]

(c) During pumping process of a copper vapour laser, electron collisional excitation occurs from its ground state to both the upper laser level, and the lower metastable laser level. The population percentage received by these levels depends on the electron temperature.

(i) Explain laser pulse evolution when discharge current is initiated in a copper vapour laser.

[5 marks]

(ii) Propose two techniques for depopulation of the lower laser level in a copper vapour laser.

[2 marks]

(d) A helium-neon laser with a gain length of 0.2 m is installed in a two-mirror cavity having mirror reflectivities of 99.9% and 98%. Evaluate the single-pass gain in the laser tube if the discharge current is sufficiently high for the gain to be four times of its lasing threshold value. Assume that there are scattering losses of 0.2% per pass within the cavity.

[5 marks]

Continued...

Question 3

(a) (i) You have just recruited a fresh graduate to operate a high-power laser beam for deep penetrating welding. Prepare a short training note that explains the physical processes that occur during the deep penetrating welding using a high-power laser beam. Use a suitable illustration to better convey the welding processes.

[5 marks]

(ii) You planned to change from using a continuous wave (CW) to a pulsed CO_2 laser for the deep penetrating welding. The young engineer immediately suggested a symmetrical pulse shape. With the aid of a suitable diagram, propose an alternative pulse shape for a more efficient welding.

[5 marks]

(b) (i) Evaluate the primary properties of laser welding that make it appealing to micro-welding application.

[5 marks]

(ii) Discuss the importance of using a laser with suitable wavelength when performing welding of metallic materials in micro-circuitry.

[5 marks]

(c) You are working in a manufacturing company that involves cutting tough materials. You are proposing to your employer to adopt laser-assisted machining. Present an explanation on the processes involved during the cutting procedure, and convince them by providing two of its advantages.

[5 marks]

Continued...

Question 4

(a) Measurements involving diffraction can be used in a variety of ways to determine dimensions of fine and thin objects. Propose a method to measure the flatness or waviness of a surface.

[8 marks]

(b) You are working with a company selling ring laser gyroscopes. While engaging with a potential customer, they raise a concern on the "*lock-in*" issue. Present a detailed description (with the aid of a suitable graph) on this issue, and the conceptual solution incorporated in your product.

[10 marks]

(c) With the aid of a suitable schematic, propose a procedure for readout of the beat frequency of a ring laser gyroscope.

[10 marks]

(d) An equilateral triangular ring laser gyroscope has a laser wavelength of 632.8 nm. If the ring laser is rotated about its centre axis which is perpendicular to its ring plane at a rate of 30° per hour and the measured beating frequency is 10 Hz, determine the lateral dimension of the ring laser.

[5 marks]

Continued...

Appendix A

Physical Constants and Units

Constant	Symbol	Value (mks units)
Speed of light in vacuum	c	3×10^{8} m/s
Electron charge	q	1.602×10^{-19} C
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Permittivity of free space	ε_0	8.8542×10^{-12} F/m
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ N/A^2
Electron volt	eV	1 eV = 1.602×10^{-19} J
Planck's constant	h	6.626×10^{-34} J·s

End of paper